MATERNAL BODY WEIGHT, WEIGHT GAIN DURING PREGNANCY, HEIGHT AND PREGNANCY OUTCOME

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Introduction:

Epidemiology of pregnancy outcome has long been a major interest in the field of maternal-and-child health. Many factors have been studied which may influence fetal and neonatal morbidity and mortality, including a wide variety of maternal characteristics and obstetric services provided (1-20).

To evaluate the effect of "prenatal care" upon pregnancy outcome, we conducted a comprehensive epidemiologic study in Southcentral Pennsylvania which considered a large number of variables, including maternal, provider and care characteristics, as well as medical-obstetric histories and labor-delivery attributes(21-23). The present paper deals with one maternal variable, namely, pre-pregnancy body weight, height and weight gain during pregnancy, as it relates to pregnancy outcome measures.

Method:

For the purpose of the present study we considered all deliveries, live or dead, at five participating hospitals located within the Greater Harrisburg Metropolitan Area during the July 1974-June 1978 period. Most of the mothers included in the study lived within two counties covering urban, suburban and rural communities.

Three different sources of data were utilized, including (a) personal interview questionnaire directed toward women who had undergone a recent pregnancy experience, (b) obstetric-infant medical records maintained at participating hospitals, and (c) birth and death certificates compiled by the State Health Department. Names and addresses of the study women were identified through the participating hospitals. Participating women were then interviewed

at their homes by a trained interviewer at approximately one month postpartum. Subsequent review and abstraction of pertinent hospital medical records followed personal interview and aquisition of a signed consent form for each participant. Data recorded on birth and death certificates provided missing information in some cases or otherwise complemented the already collected information. Approximately 4% of the women initially identified refused to participate in the study.

Pregnancy outcome measures employed for the present study include six "dependent" variables: fetal death (born dead after 16-week gestation), neonatal death (within the first 28 days), congenital anomalies, prematurity (gestation less than 37 weeks), immaturity (birth weight 2,500 grams or less), and low Apgar score (less than 7 at one minute). In our study, any defects or anomalies at birth that were recorded as "congenital" either in the hospital medical charts or birth certificates, were defined as "congenital anomalies"; all multiple conditions, if recorded, were identified and included for analysis.

A large number of "independent" variables that are known or suspected to affect pregnancy outcome were considered, including (a) those pertaining to the mother's sociopsychological-demographic attributes, prior medical and obstetric histories, and prior birth control practice; (b) those related to maternal behavior and medical activities during the index pregnancy, such as smoking, drinking, pregnancy complications, medications, prenatal care in terms of providers, trimester visits and frequency of visits, special procedures, maternal body weight gain, and employment termination; (c) those associated with labor, anesthesia, and delivery; and (d) those related to the index child characteristics, such as birth order, sex, and plurality.

Because of the extremely large number and complexity of "independent" variables considered and intercorrelations among them, it was necessary to apply a

model of multiple regression for analysis. For the purpose of this report, we used the classical least-square method. When the sample size is large, as is the case in the present study, the classical least-square can still be unbiased and asymptotically efficient when dealing with dichotomous or dummy variables(24).

A birth conforms to any of the six pregnancy outcome measures under study. Quantification of each variable was performed as follows: A value (score) of one was recorded for a given "dependent" variable, such as "fetal death," while a value (score) of zero was recorded for "live birth" (otherwise). Likewise, a value (score) of one was recorded for a given "independent" variable, such as "nonwhite," while a value (score) of zero was recorded for "white" (otherwise).

Conversion (quantification) of all the variables in this manner resulted in a total of 279 variables, discrete and mutually exclusive.

In order to reduce the number of variables to a manageable size for meaningful multiple regression analysis, two statistical techniques were employed for screening and identifying more important (in a statistical sense) variables. First, a simple-order correlation matrix was developed to examine pairwise association among independent variables for possible multicollinearity. If a pair of variables showed simple-order correlation significant at the $P \leq .10$ level by a two-tailed test, one of the variables in the pair was selected. Through this screening method, 85 variables were retained. These 85 variables were further reduced to 54 by examining the results of a series of regression analyses. In each performance of such regression, adjusted R^2 was used as the selection criterion for all the variables included in the final multiple regression equation.

Results:

Relationship between maternal body weight and pregnancy outcome was analyzed in three broad perspectives: (A) an overall body weight/gain during pregnancy matrix for the entire study population; (B) body weight gain by maternal characteristics, infant birth order, provider categories and instructions given during pregnancy; and (C) pregnancy outcome (incidence and multiple regression) according to the prepregnancy weight/gain during pregnancy matrix and by the maternal "ponderal index" based on the maximum body weight during the index pregnancy.

A. Overall Weight/Gain Matrix

Table 1 contains an overall matrix of the total 13,058 pregnancies according to the maternal prepregnant body weight and the amount of weight gained during the index pregnancy.

As shown in this table, approximately 38% and 37% of the total population reported a prepregnancy body weight of 100-124 pounds and 125-149 pounds, respectively. At two extremes, 4% weighed less than 100 pounds and 5% weighed 200 pounds or more.

With respect to the amount of weight gained during the index pregnancy, by far the largest proportion (39.5%) represented those who gained 20 to 29 pounds; this was followed by those who gained 30 to 39 pounds (24.2%), 10 to 19 pounds (19.1%), 40 to 49 pounds (7.7%), 50 pounds or more (5.1%) and less than 10 pounds (4.5%) in this order.

When original weight and gain during pregnancy were considered together, the most common combination (16.6%) was represented by those who had a

prepregnancy weight of 100 to 124 pounds and who gained 20 to 29 pounds while pregnant. This was followed by a group representing those who weighed 125 to 149 pounds initially and who gained 20 to 29 pounds while pregnant.

Two extraordinary features are shown in Table 1 . First, for women whose prepregnancy body weight ranging from 175 pounds to 199 pounds, nearly 50% gained less than 20 pounds while pregnant, as compared to only 23% who gained 30 pounds or more. Second, for the heaviest group of women weighing at least 200 pounds initially, as many as 40% of them gained 50 pounds or more, whereas 21% of them gained less than 10 pounds during pregnancy. The proportion of this heaviest group gaining between 20 and 39 pounds was much smaller (18%) than that of other original weight groups gaining the same amount of weight during pregnancy (44% to 70%).

B. Maternal Body Weight Gain

Before considering pregnancy outcome, we determined what factors were associated with the amount of maternal body weight gained during the index pregnancy.

1. Maternal Race:

Relationship between maternal race and body weight gain during pregnancy was analyzed and the results are presented in Table 2. The proportion of nonwhite women gaining less than 20 pounds was relatively larger (28.7%) than that of white women gaining the same amount of weight (22.8%). Likewise,

TABLE 1 : MATERNAL BODY WEIGHT MATRIX: ORIGINAL AND GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) During Pregnancy						
	Less than 10	10-19	20-29	30-39	40-49	50 or More	Total
Less than 100	9(0.1)	114 (0.9)	221 (1.7)	118 (0.9)	34(0.3)	11(0.1)	507 (3.9)
100 to 124	87(0.7)	898 (6.9)	2,171(16.6)	1,272 (9.7)	366(2.8)	149(1.1)	4,943 (37.9)
125 to 149	134(1.0)	866 (6.6)	1,980(15.2)	1,310(10.0)	415(3.2)	170(1.3	4,875 (37.3)
150 to 174	115(0.9)	327 (2.5)	516 (4.0)	346 (2.6)	133(1.0)	68(0.5)	1,505 (11.5)
175 to 199	109(0.8)	176 (1.3)	184 (1.4)	82 (0.6)	38(0.3)	15(0.1)	604 (4.6)
200 or more	132(1.0)	108 (0.8)	82 (0.6)	34 (0.3)	15(0.1)	253(1.9)	624 (4.8)
Total	586(4.5)	2,489(19.1)	5,154(39.5)	3,162(24.2)	1,001(7.7)	666(5.1)	13,058(100.0)
Less than 100	1.8	22.5	43.6	23.3	6.7	2.2	100%
100 to 124	1.8	18.2	43.9	25.7	7.4	3.0	100%
125 to 149	2.7	17.8	40.6	26.9	8.5	3.5	100%
150 to 174	7.6	21.7	34.3	23.0	8.8	4.5	100%
175 to 199	18.0	29.1	30.5	13.6	6.3	2.5	100%
200 or more	21.2	17.3	13.1	5.4	2.4	40.5	100%
Total	4.5	19.1	39.5	24.2	7.7	5.1	100%

Note: Cases with unknown information are excluded.

TABLE 2 : MATERNAL ORIGINAL BODY WEIGHT BY RACE AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Race							
	White				Nonwhite			
	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More
Less than 125	4,742	918	3,357	467	707	190	424	93
125 to 174	5,655	1,246	3,750	659	722	196	399	127
175 or more	1,013	440	334	239	214	85	48	81
Total	11,410	2,604	7,441	1,365	1,643	471	871	301
Less than 125	100.0	19.4	70.8	9.8	100.0	26.9	60.0	13.2
125 to 174	100.0	22.0	66.3	11.7	100.0	27.1	55.3	17.6
175 or more	100.0	43.4	33.0	23.6	100.0	39.7	22.4	37.9
Total	100.0	22.8	65.2	12.0	100.0	28.7	53.0	18.3

relatively more nonwhite women (18.3%) also gained 40 pounds or more than did white women (12.0%).

In contrast, the proportion of those who gained 20 to 39 pounds during pregnancy was much greater among white women (65.2%) than among nonwhite women (53.0%).

The racial difference described above were equally shown for all the original body weight groups except for the heaviest group. Specifically, relatively more (43.4%) of the white women weighing 175 pounds or more gained less than 20 pounds than did the nonwhite counterpart (39.7%).

2. Maternal Age:

Relationship between maternal age and body weight gain during pregnancy was analyzed and the results are presented in Table 3. The data indicate that, in general, as the maternal age advances the amount of body weight gain during pregnancy becomes less. Specifically, among the youngest women (less than 20 years) the proportion of those who gained 40 pounds or more was the largest (20.5%); the proportion gradually declined to 11.4% and 8.8% for the 20-35 year and over 35 year groups, respectively.

The general pattern of body weight gain during pregnancy as described above remained the same for all three groups of women classified according to their original body weight. It is noteworthy that nearly 58% of the youngest women, less than 20 years of age, who originally weighed 175 pounds or more

TABLE 3 : MATERNAL BODY WEIGHT AND WEIGHT GAINED DURING PREGNANCY BY AGE

Maternal Original Weight (Pounds)	Maternal Age and Weight Gain (Pounds)											
	Less than 20 yrs			20-35 yrs.			Over 35 yrs.			Total		
	Less than 20 lbs.	20-39 lbs.	40 or More lbs.	Less than 20 lbs.	20-39 lbs.	40 or More lbs.	Less than 20 lbs.	20-39 lbs.	40 or More lbs.	Less than 20 yrs.	20-35 yrs.	Over 35 yrs.
Less than 125	220	617	164	852	3,084	389	36	81	7	1,001	4,325	124
125 to 174	145	410	143	1,217	3,590	620	80	151	22	698	5,427	253
175 or more	19	29	65	471	333	224	35	20	10	113	1,028	65
Total	384	1,056	372	2,540	7,007	1,233	151	252	39	1,812	10,780	442
Less than 125	22.0	61.6	16.4	19.7	71.3	9.0	29.1	65.3	5.6	100%	100%	100%
125 to 174	20.8	58.7	20.5	22.4	66.2	11.4	31.6	59.7	8.7	100%	100%	100%
175 or more	16.8	25.7	57.5	45.8	32.4	21.8	53.8	30.8	15.4	100%	100%	100%
Total	21.2	58.3	20.5	23.6	65.0	11.4	34.2	57.0	8.8	100%	100%	100%

Note: Cases with unknown information are excluded.

gained 40 pounds or more during pregnancy, whereas only 15% of those over 35 years of age who originally weighed 175 pounds or more gained 40 pounds or more during pregnancy.

3. Birth Order:

Maternal body weight prior to, and the amount gained during the index pregnancy, was analyzed in relation to birth order. The results of this analysis are presented in Table 4.

Generally speaking, 1st-order pregnancies gained the most weight and the amount of relative gain decreased as the birth order advanced. This pattern was shown most consistently among those women whose prepregnancy weight ranged from 125 pounds to 174 pounds.

The pattern of weight gain according to original weight was quite different within the group of 1st-order pregnancies. Specifically, approximately the same proportion (32% to 34%) of those who initially weighing 175 pounds or more reported a weight gain of less than 20 pounds, 20 to 39 pounds, and 40 pounds or more, respectively.

4. Medical History:

Maternal body weight prior to, and amount gained during the index pregnancy, was analyzed in relation to medical history of the pregnant women. For this purpose we grouped the total study population into Diabetes Mellitus, Other Medical Conditions and No History. The results of this analysis are presented in Table 5.

TABLE 4 : MATERNAL ORIGINAL BODY WEIGHT BY BIRTH ORDER AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Birth Order											
	1st Order				2nd Order				3rd or Higher			
	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More
Less than 125	2,657	506	1,826	325	1,790	388	1,264	138	680	147	464	69
125 to 174	2,662	518	1,751	393	2,226	505	1,476	245	967	265	613	89
175 or more	408	140	138	130	392	185	135	72	225	112	60	53
Total	5,727	1,164	3,715	848	4,408	1,078	2,875	455	1,872	524	1,137	211
Less than 125	100.0	19.0	68.7	12.2	100.0	21.7	70.6	7.7	100.0	21.6	68.2	10.1
125 to 174	100.0	19.5	65.8	14.8	100.0	22.7	66.3	11.0	100.0	27.4	63.4	9.2
175 or more	100.0	34.3	33.8	31.9	100.0	47.2	34.4	18.4	100.0	49.8	26.7	23.6
Total	100.0	20.3	64.9	14.8	100.0	24.5	65.2	10.3	100.0	28.0	60.7	11.3

TABLE 5 : MATERNAL ORIGINAL BODY WEIGHT BY MEDICAL HISTORY AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Medical History											
	Diabetes				Other Conditions				No History			
	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More
Less than 125	57	16	35	6	4,345	883	3,015	447	868	180	600	88
125 to 174	88	17	56	15	5,184	1,193	3,353	638	929	185	623	121
175 or more	43	22	18	3	861	451	322	88	112	53	43	16
Total	188	55	109	24	10,390	2,527	6,690	1,173	1,909	418	1,266	225
Less than 125	100.0	28.1	61.4	10.5	100.0	20.3	69.4	10.3	100.0	20.7	69.1	10.1
125 to 174	100.0	19.3	63.6	17.0	100.0	23.0	64.7	12.3	100.0	19.9	67.1	13.0
175 or more	100.0	51.2	41.9	7.0	100.0	52.4	37.4	10.2	100.0	47.3	38.4	14.3
Total	100.0	29.3	58.0	12.8	100.0	24.3	64.4	11.3	100.0	21.9	66.3	11.8

The proportion of diabetic women gaining small weight (less than 20 pounds) during pregnancy was 29.3% as compared to that of women with no history (21.9%). The proportion of diabetic women gaining modal weight (20-39 pounds) was much smaller (58%) than that of women with no history (66.3%); there was a minimal difference in the relative frequency of those who gained 40 pounds or more. There were, however, some differences when maternal original body weight was considered. Specifically, for those diabetic women who originally weighed either less than 125 pounds or 175 pounds or more the proportion of small weight gain was much greater than that of counterpart among women with no history. In contrast, for those diabetic women originally weighing 125 to 174 pounds the proportion of large weight gain (40 pounds or more) during pregnancy was greater than that of counterpart among women with no history.

The pattern of body weight gain among women with other medical conditions was also different from that among women with no history, but less remarkable when compared with diabetic women. For those women whose original body weight was less than 125 pounds, there were no differences between the two groups. However, for women who originally weighed 125 to 174 pounds, relatively more of those with other medical conditions than those with no history gained smaller weight (less than 20 pounds) during pregnancy while relatively fewer of those with other medical conditions than those with no history gained a larger weight (40 pounds or more).

The pattern of body weight gains during pregnancy among those who originally weighed 175 pounds or more was similar to that among those who originally weighed 125 to 174 pounds.

5. Provider Characteristics:

Maternal body weight gain during the index pregnancy was analyzed in relation to the provider characteristics and by maternal original (before pregnancy) body weight. The results of this analysis are presented in Table 6.

Of the total pregnant population, by far the largest number were cared for by Ob/Gyn specialists (8,243); this was followed by those who went to hospital clinics (1,884), those who were treated at the teaching medical school facility (1,386), and those who were cared for by general practitioner/osteopath (1,338).

Within the Ob/Gyn group, 23.6% of the patients gained less than 20 pounds, while 10.1% of them gained 40 pounds or more during pregnancy. This general pattern prevailed within the G.P./D.O. group. In contrast, a relatively greater proportion of those patients who went to hospital clinics for care gained either less than 20 pounds or 40 pounds or more. At the teaching medical center, a relatively smaller proportion of the group experienced less than 20 pounds weight gain, but a relatively larger proportion of the group reported a gain of 40 pounds or more, as compared with the Ob/Gyn group.

TABLE 6 : MATERNAL ORIGINAL BODY WEIGHT BY PROVIDER CHARACTERISTICS AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Provider Characteristics															
	Ob/Gyn				G.P./D.O.				Clinic				Medical Center			
	Total	<20 lbs.	20-39 lbs.	≥40 lbs.	Total	<20 lbs.	20-39 lbs.	≥40 lbs.	Total	<20 lbs.	20-39 lbs.	≥40 lbs.	Total	<20 lbs.	20-39 lbs.	≥40 lbs.
Less than 125	3,439	708	2,431	300	561	95	402	64	837	215	505	117	602	82	442	78
125 to 174	4,189	925	2,808	456	653	158	416	79	828	225	452	151	681	124	465	92
175 or more	615	309	232	74	124	74	37	13	219	88	76	55	103	51	36	16
Total	8,243	1,942	5,471	830	1,338	327	855	156	1,884	528	1,033	323	1,386	257	943	186
Less than 125	100.0	20.6	70.7	8.7	100.0	16.9	71.7	11.4	100.0	25.7	60.3	14.0	100.0	13.6	73.4	13.0
125 to 174	100.0	22.1	67.0	10.9	100.0	24.2	63.7	12.1	100.0	27.2	54.6	18.2	100.0	18.2	68.3	13.5
175 or more	100.0	50.2	37.7	12.0	100.0	59.7	29.8	10.5	100.0	40.2	34.7	25.1	100.0	49.5	35.0	15.5
Total	100.0	23.6	66.4	10.1	100.0	24.4	63.9	11.7	100.0	28.0	54.8	17.1	100.0	18.5	68.0	13.4

The data also indicate that regardless of provider characteristics, as the maternal original body weight increases, the proportion of small ($<$20 lbs.) or large ($\geq$40 lbs.) gain during pregnancy increased consistently, while the opposite was the case with respect to the modal weight gain (20-39 pounds).

6. Diet Instructions:

In the study questionnaire every woman was asked if she was given diet instructions during the index pregnancy. This item was analyzed in relation to the amount of weight gained while pregnant. The results of this analysis are presented in Table 7.

In general, relatively more women who received diet instructions than those who did not receive such instructions gained more weight while pregnant. Specifically, 16.3% of those with instructions, as compared with 11.4% of those without instructions, gained as much as 40 pounds or more during the index pregnancy. In contrast, 21.7% of those with instructions gained a small weight of less than 20 pounds, while 24.3% of those without instructions gained less than 20 pounds.

When maternal original body weight was taken into account, some contrasting features emerged. Specifically, among women who initially weighed 175 pounds or more only 13.8% of those who received diet instructions reported a large gain of 40 pounds or more, as opposed to 31.3% of those who did not receive such

TABLE 7 : MATERNAL ORIGINAL BODY WEIGHT BY DIET INSTRUCTION AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Diet Instruction							
	Diet Instruction Given				Diet Instruction Not Given			
	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More
Less than 125	1,362	254	898	210	4,088	854	2,884	350
125 to 174	1,876	358	1,190	328	4,504	1,084	2,962	458
175 or more	363	168	145	50	865	357	237	271
Total	3,601	780	2,233	588	9,457	2,295	6,083	1,079
Less than 125	100.0	18.6	65.9	15.4	100.0	20.9	70.5	8.6
125 to 174	100.0	19.1	63.4	17.5	100.0	24.1	65.8	10.2
175 or more	100.0	46.3	39.9	13.8	100.0	41.3	27.4	31.3
Total	100.0	21.7	62.0	16.3	100.0	24.3	64.3	11.4

instructions. In contrast, as many as 46.3% of those who received diet instructions, as compared to 41.3% of those who did not receive such instructions, reported a small gain of less than 20 pounds while pregnant.

One additional aspect of diet instructions was considered. In the course of personal interviews every woman in the study was also asked whether or not she actually followed such instructions, if given. Maternal body weight gain during the index pregnancy was analyzed in relation to whether or not diet instructions were followed. Maternal original(prepregnancy) body weight was also taken into account. The results of this analysis are presented in Table 8.

In the total study population approximately 28% were given instructions by their providers on diet and about 24% actually followed such instructions while pregnant. These proportions varied somewhat according to the original body weight, i.e., the heavier the original weight, the greater the opportunity of receiving and/or following diet instructions.

The data also indicate that, in general, those women who gained more weight (40 pounds or more) during pregnancy were more likely to have been given diet instructions (35.3%), whereas those who gained less weight (less than 20 pounds) were less likely to have been given such instructions (25.4%). This general pattern remained the same for those whose initial (before pregnancy) body weight was less than 175 pounds.

TABLE 8 : MATERNAL ORIGINAL BODY WEIGHT BY DIET INSTRUCTION GIVEN/FOLLOWED AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Diet Instructions Given/Followed											
	Less than 20 lbs.			20 to 39 lbs.			40 lbs. or More			Total		
	Sub-Total	Instructions Given	Instructions Followed	Sub-Total	Instructions Given	Instructions Followed	Sub-Total	Instructions Given	Instructions Followed	Sub-Total	Instructions Given	Instructions Followed
Less than 125	1,108	254	223	3,782	898	784	560	210	157	5,450	1,362	1,164
125 to 174	1,442	358	327	4,152	1,190	1,043	786	328	260	6,380	1,876	1,630
175 or more	525	168	153	382	145	129	321	50	42	1,228	363	324
Total	3,075	780	703	8,316	2,233	1,956	1,667	588	459	13,058	3,601	3,118
Less than 125	100.0	22.9	20.1	100.0	23.7	20.7	100.0	37.5	28.3	100.0	25.0	21.4
125 to 174	100.0	24.8	22.7	100.0	28.7	25.1	100.0	41.7	33.1	100.0	29.4	25.5
175 or more	100.0	32.0	29.1	100.0	38.0	33.8	100.0	15.6	13.1	100.0	29.6	26.4
Total	100.0	25.4	22.9	100.0	26.9	23.5	100.0	35.3	27.5	100.0	27.6	23.9

However, for the heaviest group of women the pattern was quite different. Specifically, only 15.6% and 13.1% of those women weighing 175 pounds or more initially and who gained 40 pounds or more were given diet instructions and followed such instructions, respectively. This suggests that these very heavy women did not receive diet instructions from their providers inspite of the fact they were gaining a large amount of weight while pregnant.

7. Exercise Instructions:

Every woman included in the study was also asked if she was given exercise instructions during the index pregnancy. Maternal body weight gain during pregnancy was analyzed in relation to such instructions and the results are presented in Table 9.

As was the case with diet instructions, women who received exercise instructions also generally tended to have gained more weight than did those who did not receive such instructions. This contrasting pattern was more markedly shown among those who originally weighed from 125 to 174 pounds.

Within the group of heavy women initially weighing 175 pounds or more a larger proportion of those who received exercise instructions (52.6%) reported a small gain of less than 20 pounds as opposed to those who did not receive such instructions (41.6%). In contrast, only a very small proportion of those who received instructions (9.0%) reported a gain of 40 pounds or more, as compared to those who did not receive such instructions (28.2%).

TABLE 9 : MATERNAL ORIGINAL BODY WEIGHT BY EXERCISE INSTRUCTION AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Exercise Instruction							
	Exercise Instruction Given				Exercise Instruction Not Given			
	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More	Total	Less than 20 lbs.	20-39 lbs.	40 lbs. or More
Less than 125	659	127	449	83	4,791	981	3,333	477
125 to 174	748	138	475	135	5,632	1,304	3,677	651
175 or more	133	70	51	12	1,095	455	331	309
Total	1,540	335	975	230	11,518	2,740	7,341	1,437
Less than 125	100.0	19.3	68.1	12.6	100.0	20.5	69.6	10.0
125 to 174	100.0	18.4	63.5	18.0	100.0	23.2	65.3	11.6
175 or more	100.0	52.6	38.3	9.0	100.0	41.6	30.2	28.2
Total	100.0	21.8	63.3	14.9	100.0	23.8	63.7	12.5

One additional observation was made with respect to exercise instructions. Every woman in the study was also asked whether or not such instructions were actually carried out. Maternal body weight gain was analyzed in relation to whether or not exercise instructions were carried out and according to the original body weight. The results of this analysis are presented in Table 10.

Of the total study population, 11.8% were given exercise instructions by their providers and 9.7% actually followed such instructions while pregnant. Unlike the case of diet instructions, this pattern remained generally the same for all of the original body weight groups being compared.

The data also indicate that similarities in the proportion of receiving and/or following exercise instructions among original body weight groups were equally manifest for both small-gain (<20 lbs.) and median-gain (20-39 lbs.) groups. However, the pattern was quite different within the large-gain (>40 lbs.) group. Specifically, these women who gained 40 pounds or more during pregnancy were much more likely to have received and/or followed exercise instructions if their original weight was from 125 pounds to 174 pounds. In contrast, only a very small proportion (3 to 4%) of those women who gained a large weight (>40 lbs.) during pregnancy were given and/or followed exercise instructions if their original weight was 175 pounds or more.

TABLE 10: MATERNAL ORIGINAL BODY WEIGHT BY EXERCISE INSTRUCTIONS GIVEN/FOLLOWED AND WEIGHT GAIN DURING PREGNANCY

Maternal Original Weight (Pounds)	Weight Gain (Pounds) and Exercise Instructions Given/Followed											
	Less than 20			20 to 39			40 or More			Total		
	Sub-Total	Instructions Given	Instructions Followed	Sub-Total	Instructions Given	Instructions Followed	Sub-Total	Instructions Given	Instruotions Followed	Sub-Total	Instruotions Given	Instructions Followed
Less than 125	1,108	127	107	3,782	449	377	560	83	55	5,450	659	539
125 to 174	1,442	138	109	4,152	475	408	786	135	107	6,380	748	624
175 or more	525	70	54	382	51	44	321	12	11	1,228	133	109
Total	3,075	335	270	8,316	975	829	1,667	230	173	13,058	1,540	1,272
Less than 125	100.0	11.5	9.7	100.0	11.9	10.0	100.0	14.8	9.8	100.0	12.1	9.9
125 to 174	100.0	9.5	7.6	100.0	11.4	9.8	100.0	17.2	13.6	100.0	11.7	9.9
175 or more	100.0	13.3	10.3	100.0	13.4	11.5	100.0	3.7	3.4	100.0	10.8	8.9
Total	100.0	10.8	8.8	100.0	11.7	10.0	100.0	13.8	10.4	100.0	11.8	9.7

C. Pregnancy Outcome: Incidence Pattern

The risk of undesirable pregnancy outcome was analyzed, first, with respect to the incidence of fetal death, neonatal death, prematurity, immaturity, congenital anomalies, and low Apgar score, respectively, without taking into account other variables which may influence pregnancy outcome. This initial observation was intended to establish the pattern of such risks. The incidence rate was computed according to the 5 by 4 weight gain/original weight matrix.

1. Fetal Death:

As shown in Table 11, the overall fetal death rate was 1.9% for the entire study population. In general, the risk of fetal death is low and stable at the level of 1% for all women whose original body weight under 175 pounds. However, for heavier women weighing 175 pounds or more, the risk sharply rose to 12%.

In terms of the amount of weight gained during the index pregnancy, there was an inverse correlation with the level of fetal death rate up to 39 pounds. The risk was 6.7% for those gaining only less than 10 pounds and 0.4% for those gaining 30-39 pounds. However, for those who gained 40 pounds or more the risk of infants born dead sharply increased to the level of 8.1%. The lowest risk group was those whose weight gain ranged from 20 to 39 pounds.

The data in Table 11 indicate some further interesting features with respect to detailed weight gain indices. The risk of fetal death was associated not only with the amount of weight gain, but also with the original maternal body weight.

TABLE 11: FETAL DEATHS BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	96	12	.125	134	13	.097	115	6	.052	241	8	.033	586	39	.067
10 - 19	1,012	17	.017	866	17	.020	327	7	.021	284	2	.007	2,489	43	.017
20 - 29	2,392	12	.005	1,980	8	.004	516	4	.008	266	1	.004	5,154	25	.005
30 - 39	1,390	4	.003	1,310	6	.005	346	1	.003	116	1	.009	3,162	12	.004
40 or more	560	2	.004	585	3	.005	201	0	-	321	130	.405	1,667	135	.081
Total	5,450	47	.009	4,875	47	.010	1,505	18	.012	1,228	142	.116	13,058	254	.019

*Number of deliveries = live births plus fetal deaths.

Specifically, within the smallest weight gain group (less than 10 pounds) the risk of fetal death is the highest (12.5%) among women weighing less than 125 pounds, and the risk gradually and consistently decreased as the maternal prepregnancy weight increased (9.7%; 5.2%; 3.3%).

The risk of fetal death was small (less than 1%) and fairly stable for all original weight groups as long as they gained 20 pounds or more while pregnant.

However, there was a remarkable exception to the above observation. That is, the heaviest group of women weighing initially 175 pounds or more and who added the largest amount of weight (40 pounds or more) during pregnancy experienced an extremely high risk of fetal mortality. In this extreme group as many as 41% of infants were born dead.

2. Neonatal Death:

The results of neonatal death analysis are presented in Table 12. The overall neonatal mortality rate in the study population was 1.4 per 100 live births. In general, the risk of neonatal mortality was low (1%) and not affected by the maternal prepregnancy body weight up to 175 pounds. However, the risk sharply increased to 9% for the heaviest group of women weighing 175 pounds or more.

In terms of the amount of weight gain during the index pregnancy, the relationship found with the level of neonatal

TABLE 12: NEONATAL DEATHS BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	84	9	.107	121	5	.041	109	3	.028	233	1	.004	547	18	.033
10 - 19	995	17	.017	849	15	.018	320	3	.009	282	3	.011	2,446	38	.016
20 - 29	2,380	5	.002	1,972	18	.009	512	2	.004	265	1	.004	5,129	26	.005
30 - 39	1,386	4	.003	1,304	6	.005	345	0	-	115	1	.009	3,150	11	.003
40 or more	558	2	.004	582	2	.003	201	0	-	191	87	.455	1,532	91	.059
Total	5,403	37	.007	4,828	46	.010	1,487	8	.005	1,086	93	.086	12,804	184	.014

*Live births

mortality was similar to that of fetal mortality, but the degree of variation was less marked for neonatal mortality (3.3% for less than 10 pound group; 0.3% for 30-39 pound group). As was the case with fetal death, the risk of neonatal mortality sharply increased to 6% among those women who gained 40 pounds or more while pregnant. The lowest risk group was represented by those who gained 30-39 pounds while pregnant.

Like fetal death, the risk of neonatal mortality was associated not only with the amount of weight gained during pregnancy, but also with the level of prepregnancy body weight. Within the smallest weight gain group (less than 10 pounds) the risk of neonatal mortality was the highest (10.7%) among women weighing less than 125 pounds initially and gradually and consistently declined as the maternal prepregnancy body weight increased (4.1%; 2.8%; 0.4%).

The risk of neonatal mortality was small (less than 1%) and stable for all original weight groups as long as they gained 20 pounds or more while pregnant.

However, the heaviest group of women whose prepregnancy weight 175 pounds or more and who added the largest amount of weight (40 pounds or more) while pregnant, experienced an extremely high risk of neonatal death. In this extreme group, as many as 45.5% of infants died during the first 28 days of life.

3. Prematurity:

The results of prematurity analysis are presented in Table 13. In the total study population 6.4% of the infants were born prematurely (gestation less than 37 weeks). The pattern of prematurity incidence was similar to that of mortality in certain aspects, but different in some other aspects.

In general, the risk of prematurity was low (5% to 6%) for women whose pre-pregnancy weight ranging from 125 to 149 pounds; the risk was slightly higher (6.6%) for the lightest group (under 125 pounds) but considerably higher (10.5%) for the heaviest group (175 pounds or more).

In terms of the amount of weight gained during pregnancy, those who gained the least amount (less than 10 pounds) experienced the highest risk of prematurity (12.6%). The risk gradually decreased as the amount of weight gain increased (9.9%; 5.3%; 3.6%). As found previously, the risk of prematurity also rose considerably if the maternal weight gain exceeded 39 pounds (7.8%).

Some additional detailed features presented in Table 13 are of interest. (a) Among women weighing less than 150 pounds initially, the risk of prematurity was inversely correlated with the amount of weight gained while pregnant; the lowest risk group was represented by those who gained 30 pounds or more. (b) Among women weighing 150 pounds or more initially,

TABLE 13: PREMATURITY BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	84	19	.226	121	21	.174	109	8	.073	233	21	.090	547	69	.126
10 - 19	995	131	.132	849	78	.092	320	19	.059	282	15	.053	2,446	243	.099
20 - 29	2,380	136	.057	1,972	107	.054	512	24	.047	265	5	.019	5,129	272	.053
30 - 39	1,386	48	.035	1,304	49	.038	345	10	.029	115	5	.043	3,150	112	.036
40 or more	558	22	.039	582	17	.029	201	12	.060	191	68	.356	1,532	119	.078
Total	5,403	356	.066	4,828	272	.056	1,487	73	.049	1,086	114	.105	12,804	815	.064

*Live births

the above mentioned inverse correlation existed up to the level of 30 to 39 pound gain, beyond which the risk of prematurity rose again. Specifically, the risk for those women gaining 40 pounds or more was 6.0% if their original body weight was 150 to 174 pounds and as high as 35.6% if their original body weight was 175 pounds or more.

4. Immaturity:

Variations in the incidence of immaturity, i.e., birth weight 2,500 grams or less, are summarized in Table 14. The overall incidence of immaturity in the study population was 6.8%. As was seen in prematurity, the risk of immaturity was considerably high (8.5%) for those whose pre-pregnancy body weight ranged under 125 pounds and gradually declined (to 4.2%) as the pre-pregnancy weight increased up to the level of 174 pounds, beyond which the risk rose again to 10.3%.

With respect to the amount of maternal body weight gain, there was a consistent inverse correlation with the level of immaturity up to the level of 30-39 pound gain. Specifically, as many as 16% of the infants were born immaturely if the mother gained only 9 pounds or less whereas only 3% of the infants were born immaturely if the mother gained 30 to 39 pounds while pregnant. However, the risk rose to 7.6% if the mother gained as much as 40 pounds or more.

There were two extreme risk groups. (a) The lightest (under 125 pounds) group of women who gained the least amount of weight

TABLE 14: IMMATURITY BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	84	30	.357	121	22	.182	109	10	.092	233	23	.099	547	85	.155
10 - 19	995	183	.184	849	82	.097	320	15	.047	282	12	.043	2,446	292	.119
20 - 29	2,380	166	.070	1,972	84	.043	512	20	.039	265	6	.023	5,129	276	.054
30 - 39	1,386	54	.039	1,304	37	.028	345	9	.026	115	5	.043	3,150	105	.033
40 or more	558	25	.045	582	17	.029	201	9	.045	191	66	.346	1,532	117	.076
Total	5,403	458	.085	4,828	242	.050	1,487	63	.042	1,086	112	.103	12,804	875	.068

*Live births

(less than 10 pounds) had an exceptionally high risk of 35.7%. (b) The heaviest (175 pounds or more) group of women who gained the most amount of weight (40 pounds or more) also experienced an exceptionally high risk of 34.6%

5. Congenital Anomalies:

Variations in the incidence of congenital anomalies are summarized in Table 15. The overall incidence in the study population was 8.3%. As can be seen in the data, the risk of congenital anomalies did not fluctuate by body weight as much as that of mortality or maturity problems presented earlier.

The risk of congenital anomalies according to the maternal original body weight was fairly stable at the 8% to 9% level and only slightly elevated to 11% for the heaviest group of women weighing 175 pounds or more initially. Differences in the risk of congenital anomaly according to the amount of maternal body weight gain during pregnancy were minimal ranging from the lowest (7.3%) in the 20-29 pound gain group to the highest (10%) in the two extreme weight gain groups, namely, less than 10 pounds and 40 pounds or more.

One consistent and marked relationship was found between maternal original body weight and the amount of gain during pregnancy. Specifically, among those women who added the largest amount of weight (40 pounds or more) the risk of congenital anomaly was the lowest if their pre-pregnancy body weight was the lightest (under

TABLE 15: CONGENITAL ANOMALIES BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	84	8	.095	121	16	.132	109	9	.083	233	19	.082	547	52	.095
10 - 19	995	77	.077	849	83	.098	320	19	.059	282	29	.103	2,446	208	.085
20 - 29	2,380	179	.075	1,972	133	.067	512	44	.086	265	17	.064	5,129	373	.073
30 - 39	1,386	134	.097	1,304	101	.077	345	30	.087	115	9	.078	3,150	274	.087
40 or more	558	39	.070	582	50	.086	201	26	.129	191	41	.215	1,532	156	.102
Total	5,403	437	.081	4,828	383	.079	1,487	128	.086	1,086	115	.106	12,804	1,063	.083

*Live births

125 pounds) and the risk increased steadily and remarkably as the original body weight increased.

6. Low Apgar Score:

The incidence of "low" (less than 7) Apgar score at one minute was evaluated in relation to the maternal body weight complex and the results of this analysis are presented in Table 16.

The overall incidence of "low" Apgar score in the total study population was 9.5%. The pattern of "low" Apgar score in the weight gain—original weight matrix was different from that of mortality and maturity problems.

In terms of the maternal pre-pregnancy body weight, the risk of "low" Apgar score was slightly less for the middle-weight groups, namely, 125-149 pounds (8.2%) and 150-174 pounds (8.6%) than for either the lighter group (10.3%) or the heavier group (12.2%).

Likewise, the risk of "low" Apgar score was the lowest for the middle weight gain groups, namely, 30-39 pounds (8%) and 20-29 pounds (9%) as compared with the smaller gain groups (11% and 15%) and with the larger gain group (10%).

When both original weight and gain during pregnancy were considered together, it was noted that the risk of "low" Apgar score within the heaviest weight group (175 pounds or more) did not fluctuate much according to the amount of weight gained

TABLE 16: LOW APGAR SCORE BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Maternal Weight Gain During Pregnancy (lbs.)	Maternal Original Body Weight (lbs.)														
	Under 125			125-149			150-174			175 or More			Total		
	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate	Total*	Affected	Rate
Less than 10	84	16	.190	121	19	.157	109	12	.110	233	34	.146	547	81	.148
10 - 19	995	124	.125	849	90	.106	320	26	.081	282	26	.092	2,446	266	.109
20 - 29	2,380	225	.095	1,972	141	.072	512	51	.100	265	30	.113	5,129	447	.087
30 - 39	1,386	125	.090	1,304	100	.077	345	24	.070	115	17	.148	3,150	266	.084
40 or more	558	66	.118	582	46	.079	201	15	.075	191	26	.136	1,532	153	.100
Total	5,403	556	.103	4,828	396	.082	1,487	128	.086	1,086	133	.122	12,804	1,213	.095

*Live births

during pregnancy. The general pattern of fluctuation as described earlier prevailed in all other original body weight groups being compared.

D. Pregnancy Outcome: Multiple Regression Analysis

It is known that many factors (variables) can affect pregnancy outcome. Therefore, it is necessary to take into account such influences when the effect of maternal body weight upon pregnancy outcome is evaluated. For this purpose standard (least square) multiple regression technique was employed.

a. Weight/Gain Matrix:

First, the total number of pregnancies under study was grouped into the following six categories according to the combined indices of the maternal original body weight and the amount of weight gained during the index pregnancy:

	(Initial Weight)	(Weight Gain)
Small/Small Gain:	Less than 125 pounds	less than 20 lbs.
Small/Large Gain:	Less than 125 pounds	40 lbs. or more
Large/Small Gain:	150 lbs. or more	less than 20 lbs.
Large/Large Gain:	150 lbs. or more	40 lbs. or more
Partial Extreme: (combined)	125-149 pounds	less than 20 lbs.
	125-149 pounds	40 lbs. or more
	Less than 100 pounds	20-39 lbs.
	150 lbs. or more	20-39 lbs.
Standard (Criterion):	100-149 pounds	20-39 lbs.

Each of the four "extreme" groups and the combined "partial extreme" group was compared with the "Standard (Criterion)" group with respect

to each of the six pregnancy outcome measures; namely, fetal death, neonatal death, congenital anomalies, immaturity, prematurity, and low Apgar score. In such comparisons, the influences of 54 variables were taken into account simultaneously so that the effect of maternal body weight complex can be more clearly detected. The results of these analyses are presented in Tables 17 through 22.

1. Fetal Mortality:

As shown in Table 17, the risk of fetal death in the "Small/Small Gain," group (2.6 per 100 deliveries) was significantly higher than the "Standard" group (0.4 per 100 deliveries). More specifically, other factors being equal, the risk in the "Small/Small Gain" group was 1.6% higher than that in the "Standard" group. There were no such differences in the "Small/Large Gain" group; in other words, the amount of weight gain is an important factor. The risk of fetal death in the "Large/Small Gain" group (2.4 per 100 deliveries)was similar to that in the "Small/Small Gain" group, i.e., women weighing 150 pounds or more originally, but gained a relatively small weight have a significantly increased risk of infants being born dead.

In contrast, within the "Large/Large Gain" group, the risk of fetal death is remarkably high (24.9 per 100 deliveries). Stated in another way, nearly 15% more infants in this group were born dead when compared to the "Standard (Criterion)" group. This indicates that gaining weight during pregnancy, as such, is not always desirable and that the risk must be assessed in relation to the maternal prepregnancy body weight.

TABLE 17: FETAL DEATH BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Deliveries	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,108	29	.026	0.0162	0.0042	15.25	< 0.01
Small/Large Gain	560	2	.004	0.0012	0.0056	0.04	N.S.
Large/Small Gain	967	23	.024	0.0159	0.0044	12.87	< 0.01
Large/Large Gain	522	130	.249	0.1452	0.0065	500.08	< 0.01
Partial Extreme	3,168	41	.013	0.0076	0.0028	7.60	< 0.01
Standard (Criterion)	6,733	29	.004	-	-	-	-

2. Neonatal Mortality:

The results of neonatal mortality analysis are summarized in Table 18. As can be seen from this table, the pattern of neonatal mortality is different from that of fetal mortality. The risk of infants dying within the first 28 days of life was significantly higher only in two groups, but not in the remaining three groups. Specifically, within the "Large/Large Gain" group the incidence was as high as 25.9 per 100 live births and within the "Small/Small Gain" group the incidence was 2.4 per 100 live births. Other factors being equal, the risk of infants dying during the first 28 days within the "Large/Large Gain" group was 10.5% greater than the "Standard (Criterion)" group, whereas the same within the "Small/Small Gain" group was 1.6% greater than the "Standard (Criterion)" group.

Incidence of neonatal mortality in the three other groups varied from 0.4 per 100 births to 1.1 per 100 births, as compared to 0.5 per 100 births in the "Standard (Criterion)" group.

3. Immaturity:

Summarized in Table 19 are the incidences of immaturity by maternal body weight complex and the results of multiple regression analyses. The incidence of immaturity (birth weight 2,500 grams or less) in the "Standard (Criterion)" group was 4.6 per 100 live births. The incidence of immaturity was significantly greater than the "Standard (Criterion)" group in the following three groups: "Small/Small Gain," in which nearly 20 per 100 births were affected; "Large/Large Gain," in which 22 per 100 births were affected; and "Partial Extreme," in which 6 per 100 births were affected.

TABLE 18: NEONATAL DEATH BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,079	26	.024	0.0156	0.0038	17.11	< 0.01
Small/Large Gain	558	2	.004	0.0001	0.0051	0.00	N.S.
Large/Small Gain	870	10	.011	0.0026	0.0040	0.43	N.S.
Large/Large Gain	336	87	.259	0.1050	0.0059	319.03	< 0.01
Partial Extreme	3,257	27	.008	0.0033	0.0025	1.70	N.S.
Standard (Criterion)	6,704	32	.005	-	-	-	-

TABLE 19: IMMATURITY BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,079	213	.197	0.1425	0.0086	278.07	< 0.01
Small/Large Gain	558	25	.045	-0.0138	0.0116	1.42	N.S.
Large/Small Gain	870	60	.069	0.0162	0.0091	3.17	N.S.
Large/Large Gain	336	75	.223	0.1578	0.0134	139.55	< 0.01
Partial Extreme	3,257	195	.060	0.0125	0.0057	4.82	< 0.05
Standard (Criterion)	6,704	307	.046	-	-	-	-

When compared to the "Standard" group, other factors being equal, the risk of low birth weight within the "Large/Large Gain" group was 15.8% greater; within the "Small/Small Gain" group 14.3% greater; and within the "Partial Extreme" group 1.3% greater.

The risk within the "Small/Large Gain" group or "Large/Small Gain" group was quite similar to that of "Standard" group.

4. Prematurity:

As shown in Table 20, the incidence of prematurity (gestation less than 37 weeks)in the "Standard" group was 4.8 per 100 births. The incidence of prematurity in the "Small/Large Gain" or "Partial Extreme" group was quite similar to the "Standard" group.

Three other groups were significantly different from the "Standard (Criterion)" group. Specifically, the incidence of prematurity was as high as 23.8 per 100 births in the "Large/Large Gain" group; 13.9 per 100 births in the "Small/Small Gain" group, and 7.2 per 100 births in the "Large/Small Gain" group. Other factors being equal, the risk of premature birth was nearly 18% greater in the "Large/Large Gain" group when compared to the "Standard" group; nearly 8% greater in the "Small/Small Gain" group and 2% greater in the "Large/Small Gain" group.

These observations indicate that it is the amount of maternal body weight gain during pregnancy which relates to the risk of premature birth, but that the maternal prepregnancy body weight must be considered together in predicting the outcome of prematurity.

TABLE 20: PREMATURITY BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,079	150	.139	0.0783	0.0083	88.22	< 0.01
Small/Large Gain	558	22	.039	-0.0147	0.0113	1.69	N.S.
Large/Small Gain	870	63	.072	0.0209	0.0089	5.51	< 0.05
Large/Large Gain	336	80	.238	0.1791	0.0130	189.24	< 0.01
Partial Extreme	3,257	175	.054	0.0072	0.0055	1.68	N.S.
Standard (Criterion)	6,704	325	.048	-	-	-	-

5. Congenital Anomalies:

The pattern of congenital anomalies was further different from that of fetal or neonatal mortality. As shown in Table 21, the highest incidence of congenital anomalies was indicated in the "Large/Large Gain" group in which nearly 20 per 100 infants were born with one or more congenital anomalies. This was followed by the "Partial Extreme" group in which 9 per 100 infants were born with some type of congenital anomalies.

Other factors being equal, the risk of infants being born with one or more congenital anomalies within the "Large/Large Gain" group (8.7% above standard) or within the "Partial Extreme" group (1.3% above standard) was significantly greater when compared with the "Standard (Criterion)" group.

No significant increases were observed in the risk of congenital anomalies within either of the three other groups, namely, "Small/Small Gain," "Small/Large Gain," and "Large/Small Gain." The incidence of congenital anomalies in the Standard (Criterion) population was 7.5 per 100 live births.

These observations suggest that unlike mortality and maturity problems, congenital anomalies are not generally associated with the amount of weight gain as such, and that it is the combined factors of heavy weight and large gain during pregnancy which is important.

TABLE 21: CONGENITAL ANOMALIES BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,079	85	.079	-0.0056	0.0093	0.37	N.S.
Small/Large Gain	558	39	.070	-0.0120	0.0126	0.91	N.S.
Large/Small Gain	870	76	.087	0.0000	0.0099	0.00	N.S.
Large/Large Gain	336	67	.199	0.0870	0.0145	36.03	< 0.01
Partial Extreme	3,257	292	.090	0.0128	0.0062	4.32	< 0.05
Standard (Criterion)	6,704	504	.075	-	-	-	-

6. Low Apgar Score:

The pattern of "low" (less than 7) Apgar score at one minute was quite different from any of the five other pregnancy outcome measures considered in the study (Table 22).

Within the "Standard" group the incidence of "low" Apgar score was 8.4 per 100 births. There was only one group which showed a significant deviation from the "Standard" group. Specifically, the incidence within the "Small/Small Gain" group was 13 per 100 births; this risk, other factors being equal, was 3% greater than the "Standard" group. This observation suggests that Apgar scores are not influenced by either prepregnancy maternal body weight or by the amount of weight gained during pregnancy or by the combined weight complex, except when both are at the small extreme, i.e., only those women whose initial body weight was less than 125 pounds and who gained less than 20 pounds while pregnant were affected.

b. Ponderal Index:

Second, in addition to the original weight/weight gain complex, we considered the body form in terms of height and weight ratio. For this purpose, the concept of Ponderal Index (height/ $\sqrt[3]{\text{maximum weight during pregnancy}}$) was employed. The maximum body weight was a sum of prepregnancy weight and the amount of weight gain during pregnancy. Presented in Table 23 are Ponderal Index matrix according to the maternal height in inches and the maximum body weight (pounds) during the index pregnancy. Ponderal Indices range from the low of 10.43 to the high of 13.63. Those with an index of 11.50 through 12.49 were treated as "Standard (Criterion)."

TABLE 22: LOW APGAR SCORE BY MATERNAL INITIAL BODY WEIGHT AND WEIGHT GAIN DURING PREGNANCY

Weight Groups (Maternal)	Number of Live Births	Number Affected*	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Small/Small Gain	1,079	140	.130	0.0297	0.0098	9.25	< 0.01
Small/Large Gain	558	66	.118	0.0229	0.0132	2.98	N.S.
Large/Small Gain	870	98	.113	0.0037	0.0104	0.12	N.S.
Large/Large Gain	336	41	.122	0.0117	0.0153	0.59	N.S
Partial Extreme	3,257	305	.094	0.0029	0.0065	0.20	N.S.
Standard (Criterion)	6,704	563	.084	-	-	-	-

*Low Apgar score at one minute.

TABLE 23: PONDERAL INDEX: HEIGHT/$\sqrt[3]{\text{WEIGHT + GAIN}}$

Maternal Body Weight (pounds)		Maternal Height in Inches							
Maximum*	Cubed	61"	62"	63"	64"	65"	66"	67"	68"
124	4.986	12.23	12.43	12.63	12.83	13.03	13.25	13.43	13.63
125	5.000	12.20	12.40	12.60	12.80	13.00	13.20	13.40	13.60
149	5.301	11.50	11.69	11.88	12.07	12.26	12.45	12.63	12.82
150	5.313	11.48	11.66	11.85	12.04	12.23	12.42	12.61	12.79
174	5.582	10.92	11.10	11.28	11.46	11.64	11.82	12.00	12.18
175	5.593	10.90	11.08	11.26	11.44	11.62	11.80	11.97	12.15
199	5.838	10.44	10.62	10.79	10.96	11.13	11.32	11.47	11.64
200	5.848	10.43	10.60	10.77	10.94	11.11	11.30	11.45	11.62

*Pre-pregnancy body weight plus weight gain during pregnancy.

The total number of pregnancies under study was grouped into the following six categories according to the level of Ponderal Index:

Less than 10.50 (lowest P.I.)	"short" and "heavy"
10.50 - 10.99 (lower P.I.)	
11.00 - 11.49 (lower P.I.)	
11.50 - 12.49 (criterion P.I.)	"standard"
12.50 - 12.99 (higher P.I.)	"tall" and "light"
13.00 or more (highest P.I.)	

1. Fetal Death:

The incidence of fetal mortality was analyzed in relation to the level of Ponderal Index and the results of this analysis are summarized in Table 24. The data indicate that only two extreme groups had a significantly increased risk of fetal mortality, i.e.,

(a) Those whose Ponderal Index less than 10.50 (short and very heavy) had an extremely high fetal death rate of 23.9 per 100 deliveries; other factors being equal, the risk in this group was approximately 14% greater than the "Standard (Criterion)" group.

(b) Those whose Ponderal Index 13.00 or more (tall and light) had an increased risk of 3.5 per 100 deliveries; other factors being equal, this risk was approximately 2% greater than the "Standard (Criterion)" group.

2. Neonatal Death:

The incidence of neonatal mortality was analyzed in relation to the level of Ponderal Index and the results of this analysis are presented in Table 25.

TABLE 24: FETAL DEATH BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Deliveries	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	568	136	.2394	0.1360	0.0063	471.694	$<$0.00
10.50 - 10.99	695	6	.0086	0.0023	0.0051	0.197	N.S.
11.00 - 11.49	1,998	15	.0075	-0.0002	0.0032	0.004	N.S.
12.50 - 12.99	1,680	25	.0149	0.0053	0.0034	2.342	N.S.
13.00 or more	374	13	.0348	0.0178	0.0068	6.905	$<$0.01
11.50 - 12.49 (Criterion)	7,743	59	.0076	-	-	-	-

Ponderal Index = Height in inch/ $\sqrt[3]{\text{Weight* in pounds}}$.
*Weight = Initial Body Weight + Weight Gain.

TABLE 25: NEONATAL DEATH BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	432	90	.2083	0.0976	0.0057	296.472	$<$0.00
10.50 - 10.99	689	4	.0058	0.0001	0.0046	0.001	N.S.
11.00 - 11.49	1,983	12	.0061	-0.0006	0.0029	0.037	N.S.
12.50 - 12.99	1,655	22	.0133	0.0060	0.0031	3.835	$<$0.05
13.00 or more	361	10	.0277	0.0138	0.0061	5.094	$<$0.05
11.50 - 12.49 (Criterion)	7,684	46	.0060	-	-	-	-

Ponderal Index = Height in inch/ $\sqrt[3]{\text{Weight* in pounds.}}$
*Weight = Initial Body Weight + Weight Gain.

The risk of neonatal mortality was extremely high (20.8 per 100 live births) among those women with an index less than 10.50 short and very heavy); other factors being equal, the risk in this group was nearly 10% greater than the "Standard (Criterion)" group with an index ranging from 11.50 to 12.49.

The risk of neonatal mortality was also significantly higher than the "Standard (Criterion)" group in two other groups; these were (a) those women whose Ponderal Index ranging from 12.50 to 12.99 (1.3 per 100 live births) and (b) those women whose Ponderal Index 13.00 or more (tall and light).

3. Congenital Anomalies:

The incidence of congenital anomalies was analyzed in relation to the level of Ponderal Index and the results of this analysis are presented in Table 26.

The pattern of congenital anomalies by Ponderal Index was different from that of fetal or neonatal mortality. There was only one group which showed a significant deviation from the "Standard" group. Specifically, the incidence of congenital anomalies among those women with an index less than 10.50 was 14.1 per 100 live births as compared with the "Standard" group (7.9 per 100 live births). Other factors being equal, the risk in this extreme group (short and very heavy) was approximately 6% greater than that of the "Standard" group. The incidence of congenital anomalies in all other groups being compared was quite similar, ranging from 7.9 to 9.1 per 100 births.

TABLE 26: CONGENITAL ANOMALIES BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	432	61	.1412	0.0555	0.0140	15.721	<0.01
10.50 - 10.99	689	58	.0842	-0.0022	0.0114	0.039	N.S.
11.00 - 11.49	1,983	171	.0862	0.0030	0.0072	0.178	N.S.
12.50 - 12.99	1,655	131	.0792	-0.0068	0.0077	0.782	N.S.
13.00 or more	361	33	.0914	-0.0007	0.0151	0.002	N.S.
11.50 - 12.49 (Criterion)	7,684	609	.0793	-	-	-	-

Ponderal Index = Height in inch/ $\sqrt[3]{\text{Weight}^*}$ in pounds.
*Weight = Initial Body Weight + Weight Gain.

4. Prematurity:

Prematurity (gestation less than 37 weeks) was related to Ponderal Index and the results of this analysis are summarized in Table 27.

The pattern of premature births was quite different from that of previous analyses in some respects. The incidence of prematurity among those women with an index ranging from 11.00 to 11.49 was only 4.3 per 100 births, which was significantly lower than the "Standard" group (5.2 per 100 births) with an index of 11.50 to 12.49. Other factors being equal, the risk of prematurity in this group was 1.3% less than the "Standard" risk as defined in the present study.

In contrast, the incidence of prematurity among short and heavy women with an index less than 10.50 was extremely high (20.1 per 100 births); other factors being equal, this risk was approximately 17% greater than the "Standard" group. On the other hand, some of the tall and slim women also carried a significantly greater risk. Specifically, 9.7% of infants born of those women with an index ranging from 12.50 to 12.99 were delivered prematurely; the risk in this group was 4% greater than the "Standard" group when all other variables were taken into account. Likewise, the incidence of prematurity among tall and very heavy women with an index 13.00 or higher was 14.1 per 100 births; the risk in this group was 8% greater than the "Standard" group when the influences of all other variables in the study were held constant.

TABLE 27: PREMATURITY BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	432	87	.2014	0.1671	0.0126	177.013	<0.00
10.50 - 10.99	689	31	.0450	-0.0138	0.0102	1.816	N.S.
11.00 - 11.49	1,983	85	.0429	-0.0132	0.0065	4.210	<0.05
12.50 - 12.99	1,655	161	.0973	0.0404	0.0069	34.397	<0.01
13.00 or more	361	51	.1413	0.0760	0.0136	31.447	<0.01
11.50 - 12.49 (Criterion)	7,684	400	.0521	-	-	-	-

Ponderal Index = Height in inch/$\sqrt[3]{\text{Weight}^*}$ in pounds.
*Weight = Initial Body Weight + Weight Gain.

5. Immaturity:

Immaturity (birth weight 2,500 grams or less) was analyzed in relation to the level of Ponderal Index and the results of this analysis are presented in Table 28.

The pattern of immaturity by Ponderal Index was generally similar to that of prematurity described earlier. As was the case with prematurity, the risk of immaturity was also the lowest for those women with an index ranging from 11.00 to 11.49. In this group 4.5 per 100 births, as compared to 5.5 per 100 births in the "Standard" group, were born with low birth weight. After adjusting simultaneously for the influences of all other variables considered in the study, this risk of immaturity was approximately 1.6% less than the "Standard" group.

In contrast, short-and-very heavy women, as well as some of tall-and-slim women both experienced a significantly greater risk of immaturity than the "Standard" group. Specifically, approximately 20% of women with an index less than 10.50 (short and very heavy) reported prematurity; after influences of all other variables were taken into account, the risk in this group was 15% greater than the "Standard" group. On the other hand, 10.9% of tall and slim women with an index ranging from 12.50 to 12.99 and 18.6% of tall-and-slim women with an index 13.00 or higher reported immature births; the risk in these groups was 5% and 11% greater than the "Standard" group, respectively, after other influences have been taken into account.

TABLE 28: IMMATURITY BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	432	85	.1968	0.1511	0.0130	136.198	<0.00
10.50 - 10.99	689	34	.0493	-0.0165	0.0105	2.447	N.S.
11.00 - 11.49	1,983	90	.0454	-0.0156	0.0067	5.522	<0.05
12.50 - 12.99	1,655	180	.1088	0.0499	0.0071	49.513	<0.01
13.00 or more	361	67	.1856	0.1141	0.0140	66.590	<0.01
11.50 - 12.49 (Criterion)	7,684	419	.0545	-	-	-	-

Ponderal Index = Height in inch/$\sqrt[3]{\text{Weight*}}$ in pounds.
*Weight = Initial Body Weight + Weight Gain.

6. Low Apgar Score:

The overall pattern of low Apgar score was different from any of the other five outcome measures being studied. The relationship between Ponderal Index and low Apgar score is shown in Table 29.

In general, the incidence of low Apgar score did not vary appreciably according to the level of Ponderal Index. In two groups, however, the risk was significantly elevated when compared with the "Standard" group.

Specifically, the incidence of low Apgar score among short-and-very heavy women with an index less than 10.50 was 14.6 per 100 births as compared with 8.5 per 100 births in the "Standard" group; other factors being equal, the risk in this extreme group was 4.7% greater than the "Standard" group.

Unlike all other pregnancy outcome measures in the study, the incidence of low Apgar score among women in the largest Ponderal Index (tall-and-slim) was not significantly different from the "Standard" group. In contrast, slim women with middle height or tall women with middle weight with an index ranging from 12.50 to 12.99 reported a significantly higher incidence (11.4 per 100 births) than the "Standard" group; other factors being equal, the risk of low Apgar score in this group was 2.3% greater than the "Standard" group.

TABLE 29: LOW APGAR SCORE BY SIX PONDERAL INDEX GROUPS

Ponderal Index	Number of Live Births	Number Affected	Incidence Rate	Regression Coeff. (B)	Standard Error of B	F Ratio	P Value
Less than 10.50	432	63	.1458	0.0467	0.0147	10.127	<0.01
10.50 - 10.99	689	69	.1001	-0.0000	0.0120	0.000	N.S.
11.00 - 11.49	1,983	200	.1009	0.0069	0.0076	0.827	N.S.
12.50 - 12.99	1,655	189	.1142	0.0233	0.0081	8.366	<0.01
13.00 or more	361	43	.1191	0.0181	0.0159	1.307	N.S.
11.50 - 12.49 (Criterion)	7,684	649	.0845	-	-	-	-

Ponderal Index = Height in inch/ $\sqrt[3]{\text{Weight*}}$ in pounds.
*Weight = Initial Body Weight + Weight Gain.

Summary and Discussion:

Among many variables that influence pregnancy outcome, maternal body weight has been considered to be of etiological importance, yet there has been no comprehensive study of such variable based on a large cross-sectional population. Our study based on 13,058 single births, although not originally intended for such purpose, did provide an opportunity to investigate how maternal body weight, prepregnant and gain during pregnancy, and height mix affects early mortality, maturity problems, congenital malformations, and Apgar score. Our data, derived from a total cross-sectional population, included an entire body weight range from less than 100 pounds to over 200 pounds. Another important feature of our study is the fact that a large number of independent factors (initially over 200; reduced to 54 for final analysis) were considered. This made it possible to adjust simultaneously the influences of all such factors so that the impact upon pregnancy outcome of the maternal body weight can be more clearly detected.

While maternal weight/gain complex and how it relates to pregnancy outcome is of primary importance, we first considered what factors are associated with maternal weight gain during pregnancy. Several interesting features emerged. Relatively more nonwhite women than white women gained either small or large weight during the index pregnancy. As the maternal age advanced, the amount of body weight gain during pregnancy decreased. Related to the maternal age was birth order; first-order pregnancies gained the most weight and the amount of gain during pregnancy decreased as the birth order advanced.

Both prepregnancy body weight and gain during pregnancy are special interest to providers, particularly when patients have certain medical conditions. For this reason, we separated women with diabetes mellitus, women with other medical conditions such as hypertension, heart disease, kidney disease, etc. from those without any major medical history. Diabetes is an especially important condition because such patients are under special diet and/or weight control regardless of being pregnant. It is clear from our data that diabetic women gained relatively much less than did women with no major medical history. This contrast was much more marked for those diabetics weighing either less than 125 pounds or more than 175 pounds before being pregnant. A similar, but less prominent pattern was shown for women with other medical conditions.

How maternal body weight changes according to provider is also of particular interest. Our data indicated that the pattern of weight gain did not differ appreciably among Ob/Gyn specialists, General Practitioners, and Osteopaths; however, relatively more of those patients who went to hospital clinics for care gained either a large or small weight while pregnant. In part, this may be explainable in terms of racial difference as described earlier.

It was of special interest to determine whether or not diet instructions, if given by the provider, were reflected on the amount of body weight gain during pregnancy. Our data suggest that diet instructions were given the patients when they had manifested "weight problems" during pregnancy rather than as a preventive measure based on the maternal prepregnancy weight. However, our data also suggest that, among heavy

women initially weighing 175 pounds or more, those with diet instructions gained less than those without such instructions. Some of those who received diet instructions failed to follow through such advice.

We also evaluated how exercise instructions, if offered by the provider, affected maternal body weight gain. The relationship between exercise instructions and weight gain was generally similar to that between diet instructions and weight gain.

Prior to the multiple regression analysis of pregnancy outcome measures, we determined the incidence of each of the six outcome measures according to the original body weight level and the amount of weight gained during pregnancy. Our data indicate that the risk of all six adverse outcome measures was much higher at two extreme levels of weight gain (lowest and highest) and the lowest risk was shown for those who gained a weight from 20 to 39 pounds while pregnant. This general pattern was particularly true in the case of immaturity and prematurity, whereas the incidence of congenital anomalies was somewhat less remarkable.

The results of comprehensive multiple regression analysis indicate that the risk of mortality (fetal and neonatal), prematurity and immaturity was generally similar when both prepregnancy body weight and weight gain during pregnancy were considered together. That is, a significantly greater risk of fetal and neonatal mortalities, immaturity, and prematurity was shown for those heavy women who gained the largest weight or for those light women who gained the smallest weight. Contrarily, a significantly increased risk of congenital anomalies was shown only

for the "large/large gain" group, whereas a significantly increased risk of low Apgar score was manifested only for the "small/small gain" group.

Thus far, only maternal body weight was considered. Since body weight is, in part, dependent upon height, we then took maternal height into consideration. In other words, the Ponderal Index which we employed, characterizes the "body form" with a two-dimensional attribute. In general, a "low" index represents a group of short women with a large body weight, whereas a "high" index represents a group of tall women with a small body weight. How this type of two-dimensional physical index affects pregnancy outcome has not yet been fully studied in the past. For the purpose of our study, a group of women with an index ranging from 11.50 to 12.49 was treated as "Standard (Criterion)" and this was compared with each of the other five groups in the course of multiple regression analysis.

The pattern of risk according to the Ponderal Index differed among the six pregnancy outcome measures under study. There were some similarities to the risk distribution by weight/weight gain mix as presented earlier. That is, greater risks of fetal and neonatal mortalities were also shown for those women with either high Ponderal Index (tall and slim) or low Ponderal Index (short and heavy).

However, a significantly increased risk of congenital anomalies was indicated only for those short and heavy women, whereas a significantly increased risk of low Apgar score was indicated for two groups of women, (a) short-and-very heavy and (b) tall-and-middle weight or middle height-and-light.

Both prematurity and immaturity were quite different according to the level of Ponderal Index. The risk of these maturity problems was the lowest among those women with an index ranging from 11.00 to 11.49 and was the highest among those women with an index less than 10.50 (short and very heavy).

While numerical distribution and adjusted perinatal risk pattern, as shown according to the maternal original body weight, weight gain during pregnancy, as well as height/weight ratio are of interest for both epidemiologists and providers who serve pregnant population, it is difficult to discern specific biological mechanism, which may offer reasonable explanation.

Several additional, more detailed or focused analyses can and should be performed of the very comprehensive and rather unique data we have ascertained in this study. A more sophisticated statistical method, such as Probit or Logit model, as well as Factor Analysis and step-wise multiple regression may be applied. Maternal prior medical and obstetric histories and prenatal care can also be analyzed in much more depth. Such analyses will enable further delineation of some specific etiological factors or mechanism for better understanding of the role of the maternal physique and weight gain during pregnancy.

The etiology of perinatal morbidity and mortality is as complex as its constituent components and variations. Our data indicate, however, that there are certain common factors which, more or less, equally affect most of the six pregnancy outcome measures under study; namely, fetal death, neonatal mortality, prematurity, immaturity, congenital anomalies, and low Apgar score.

For example, with respect to maturity problems, i.e., infants either born prematurely or with small birth weight, as well as perinatal mortality, i.e., infants either born dead or dying within the first 28 days, two contrasting common factors are equally affecting negatively the outcome; namely, (a) very low Ponderal Index of less than 10.50 (short and very heavy) or small weight gain (less than 20 pounds) during pregnancy; and (b) very high Ponderal Index of 13.00 or more (tall and very slim) or large weight gain (more than 40 pounds) during pregnancy. These findings are consistent with the fact that fetal maturity problems are closely related to perinatal mortality. Apparently at least two major different etiological mechanisms may be involved. On the one hand, a large weight gain beyond 40 pounds during pregnancy, particularly if the mother was short and very heavy initially, may produce a hostile or undesirable physical environment in which the fetus grows (i.e., limited intra-uterine space and inward pressure). On the other hand, failure to attain an adequate maternal weight during pregnancy may be related, either directly or indirectly, to the fetal ability to grow normally in utero. In this case, what causes mothers not gaining adequate body weight during pregnancy becomes a prime importance. Except when the fetus is unable to metabolize (genetic or other reasons) intake nutrients through placenta, maternal diet and nutritional care during pregnancy should be able to control the growth of maternal body weight. This, however, may be complicated by any existing medical conditions, such as diabetes, in the pregnant woman.

Our data indicate that congenital anomalies are associated with only a large body weight gained (40 pounds or more) by the mother and with

short-and-very heavy (maximum during pregnancy) women with a Ponderal Index less than 10.50. These observations suggest that the etiology of congenital anomalies is different from that of fetal maturity problems or of perinatal mortality. A separate analysis of the specific type(s) of anomalies involved should provide some clues as to the etiological process in relation to the body physique under study.

Explanation of low Apgar score pattern is difficult. In terms of the original weight/weight gain mix, the only group showing a significantly increased risk was those mothers who gained a small weight (less than 20 pounds) regardless of their prepregnancy weight. However, in terms of the Ponderal Index, two groups experienced a significantly increased risk; these are (a) short and very heavy women with an index less than 10.50 and also (b) women with an index ranging from 12.50 to 12.99 (height 63" to 64" combined with maximum weight 124 to 125 pounds; height 67" to 68" combined with maximum weight 149 to 150 pounds). From these two observations, it may be hypothesized that the Apgar score (a prognostic indicator at one minute of delivery) is affected by two factors; namely, (a) lack of gaining an adequate weight during pregnancy and (b) certain combination of maternal height and weight.

The results of the present study are of particular significance for practicing physicians and allied medical personnel who provide services for pregnant women. Clear relationships demonstrated between maternal physique — weight mix and pregnancy outcome measures, along with a systematically displayed numerical matrix, provide a convenient vehicle for predicting potential (or even likely) risks involved on an individual basis.

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